

SAR Evaluation Considerations for Laptop/Notebook/Netbook and Tablet

Computers

- Supplement to KDB 616217 -

This supplement applies to transmitters and antennas incorporated in laptop/notebook/netbook and/or tablet computers for use in laptop and/or tablet modes, including those with display screens less than 12".¹ This document may be used to determine SAR evaluation requirements for portable or mixed mobile and portable exposure conditions, to extend the earlier procedures established in KDB 616217 for laptops with larger displays and wider antenna separations.² The test requirements for both individual and simultaneous transmitting transmitters and antennas operating in the keyboard and display screen of these host computers are considered in this document. Based on the test conditions applied to individual transmitters for equipment certification, the supplemental procedures can provide certain options to minimize the tests and permissive changes needed to incorporate approved transmitters and antennas in qualified host configurations. The document does not address user installed external, peripheral transmitters and antenna configurations, such as USB, CardBus or ExpressCard devices, which are described in section 2) of KDB 447498. The procedures in this supplement are not intended for hand-held devices that may transmit in close proximity to users, such as UMPC or devices with similar form factors, which may need additional considerations.

Individual Transmitter and Antenna Considerations

When individual transmitters and antennas are tested in host computer(s) using the most conservative exposure configurations required by the intended host(s), according to procedures in sections 2) and 4) of KDB 447498, additional tests and certifications are typically not required to incorporate the approved transmitter and antenna configurations in qualified host configurations. However, when more conservative exposure conditions are required by subsequent products; for example, to incorporate the transmitter or new antenna configurations at even closer separations to users, Class II permissive change approvals are necessary. Additional guidance for configuring conservative SAR test configurations is included in the Appendix of this document.

Antenna gain is a far field parameter. It is generally not directly related to near-field exposure conditions, which can be highly dependent on the RF current distribution characteristics of the individual transmitter, antennas and host computer configurations. Without taking into consideration the near-field exposure characteristics and parameters it would be inappropriate to assume that lower gain antennas always result in lower SAR; therefore, antenna gain is generally not used to assess the SAR evaluation requirements of devices operating at close proximity to users.³

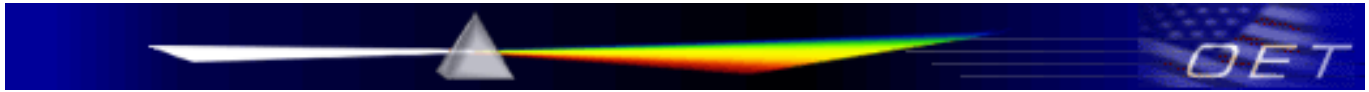
As described in KDB 616217, SAR evaluation is typically not required when the maximum transmitter and antenna output power are $\leq 60/f_{\text{(GHz)}} \text{ mW}$.⁴ The procedures allow the number of SAR tests to be

¹ See KDB Publication 447498 for definitions of laptop and tablet operating modes. Display screen dimensions are measured diagonally.

² When different transmitters and antennas transmit simultaneously according to mobile and portable exposure requirements, the laptop/notebook/netbook computer is operating in a mixed mobile and portable exposure conditions.

³ When the measured SAR is low, see section 5) of KDB 178919 for exceptions.

⁴ Source-based time-averaged conducted output power, consistent with SAR and near-field exposure requirements, is used.



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reduced when antennas are installed to operate at $\geq (5 + \frac{1}{2} \cdot n)$ cm from users.⁵ These options may continue to be applied to laptops/notebooks/netbooks provided the antennas are installed in host computers with the required minimum separation distance from users. For transmitters and modules intended for OEM integration, the trade-off between test conservativeness and implementation flexibility needs careful consideration in the initial equipment approval. More relaxed exposure conditions that require little or no tests generally lead to undesirable restrictions, which may necessitate further testing and equipment approval to incorporate the transmitter and antenna(s) in unqualified host devices and configurations. It is recommended that grantees of individual transmitters take into consideration the implementation flexibilities required by their OEM integrators and distributors to streamline test and equipment certification requirements.

Simultaneous Transmission Considerations

When multiple transmitters and antennas transmit simultaneously in a laptop/notebook/netbook or tablet computer, the following may be used to determine simultaneous transmission SAR evaluation reduction or exclusion requirements. The procedures apply to antennas in the display screen and keyboard; i.e., the entire computer, for both *laptop* and *tablet* operating modes and conditions.⁶ If antennas are incorporated in the display only with more than 5 cm separation from users, the procedures in KDB 616217 may continue to be applied. However, it is unacceptable to mix the simultaneous transmission procedures in this supplement with those in KDB 616217.

- 1) Identify all possible combinations of simultaneous transmission configurations for all transmitters and antennas installed in the display screen and keyboard of the intended host computer configurations
- 2) Transmitters/antennas operating from external card slots and/or connectors of the host computers must be more than 5 cm from any simultaneous transmitting antennas to ensure possible combined exposures due to user installed transmitters, such as Card Bus and USB devices, are insignificant; therefore, may be ignored⁷
- 3) For each simultaneous transmission configuration identified in 1) above, the following must be clearly described in the SAR report or Class I permissive change documentation to determine the SAR test reduction and exclusion requirements:^{8, 9}
 - a) FCC ID of all transmitters, maximum average conducted output power in each transmission mode and frequency band, operating configurations and exposure conditions approved for the individual transmitters¹⁰

⁵ The threshold distance $(5 + \frac{1}{2} \cdot n)$ cm is computed according to $n = P/(60/f) - 1$; where n is the number of times the antenna output power (P) is $> 60/f$. P and $(\frac{1}{2} \cdot n)$ are rounded respectively to the nearest mW and cm to determine the distance.

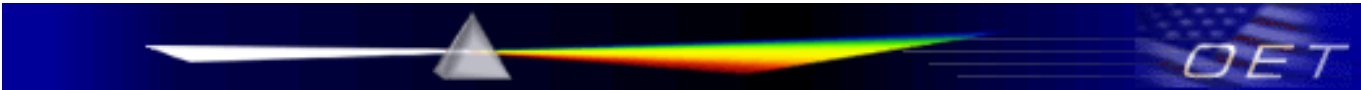
⁶ See section 4) of KDB 447498 for laptop and tablet mode definitions and test requirements.

⁷ Consider only the transmitters and antennas requiring SAR evaluation; i.e. $> 60/f_{(\text{GHz})}$ mW.

⁸ Combinations of transmitters and antennas may transmit simultaneously at different times or under different configurations; therefore, resulting in different combinations of simultaneous transmission configurations.

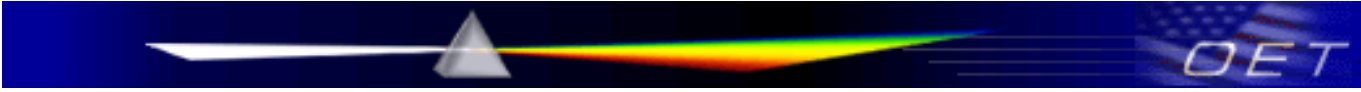
⁹ Class I Permissive Change documentation must be readily available upon request to support any subsequent Class II Permissive Change approvals; when necessary, the information may be included to expedite subsequent equipment certification.

¹⁰ Power measurements should be consistent with the wireless technology; for example, GSM/GPRS/EDGE normally reports burst average power.

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- b) applicable antenna locations for all host configurations identified in diagrams, drawings and/or photos, including the range of antenna-to-user and antenna-to-antenna separation distances to support the required test reduction and exclusion analysis or SAR test configurations¹¹
 - c) the type and physical dimensions of antennas incorporated in the intended host configurations
 - d) antenna gain specified by the antenna manufacturer for antennas qualified for mobile exposure conditions
 - e) other relevant information and restrictions required by the equipment certifications of individual transmitters, including antenna changes
 - f) the range of applicable physical, mechanical and electrical variations of host computer configurations supported by the test results in all relevant equipment certifications
- 4) For each simultaneous transmission configuration identified in 1), if the conditions in a) or b) below are satisfied and fully documented in the SAR report or Class I permissive change documentation, simultaneous transmission SAR evaluation is not required for that configuration¹²
- a) when the $[(\sum \text{ of the highest measured 1-g SAR for each portable transmitter/antenna included in the simultaneous transmission configuration}) / 1.6 \text{ W/kg}] + \sum \text{ of } [(\text{the highest MPE for each mobile transmitter/antenna included in the simultaneous transmission configuration}) / (\text{the corresponding MPE limit})] < 1$; or
 - b) for antennas included in the simultaneous transmission configuration that require SAR evaluation, when the separation distance between each antenna pair is
 - i) greater than $5 \cdot [(\text{SAR}_1 + \text{SAR}_2) / 1.6]^{1.5} \text{ cm}$, rounded to the nearest cm, and
 - ii) the $\sum \text{ of } [(\text{the highest MPE for each mobile transmitter/antenna included in the simultaneous transmission configuration}) / (\text{the corresponding MPE limit})] < 1$
- where: \sum in a) excludes antennas that do not require SAR evaluation, and
MPE does not apply to displays < 10" diagonal for both a) and b)
- 5) For each simultaneous transmission configuration identified in 1), if it does not meet the conditions described in 4), submit an inquiry to the FCC Laboratory to determine the applicable simultaneous transmission SAR evaluation procedures and if PBA or FCC filing is required
- 6) The following procedures may continue to be applied independently if deemed appropriate for the required host computer configurations; however, it is unacceptable to mix the following procedures with the supplemental procedures described in this document
- a) the simultaneous transmission SAR evaluation procedures in KDB 616217 and section 3) of KDB 447498
 - b) the procedures in section 8) of KDB 447498 for certain simple mixed mobile and portable exposure conditions
- 7) For other simultaneous transmission configurations and exposure conditions that have not been addressed in this supplement or other FCC test procedures, unless there is prior FCC consultation, SAR measurement results for simultaneous transmission are required to show compliance for equipment certification

¹¹ The closest distance between each antenna and the user and the closest distance between individual antennas should be used.

¹² The documentation applies to the initial certification and subsequent permissive changes, including Class I and II.

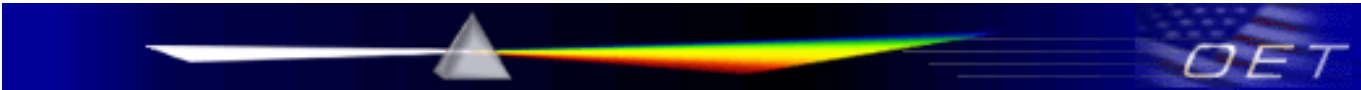
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- 8) When the operating, installation and implementation requirements and restrictions required for the individual transmitters and antennas are satisfied and SAR test exclusion applies to all the simultaneous transmission configurations identified in 1), provided there are no other filing requirements, RF exposure compliance may be addressed with respect to Class I permissive change requirements according to the documentation procedures in this supplement
 - 9) The grantee is responsible and must ensure its OEM integrators and distributors are provided with and following the necessary installation and implementation instructions/requirements and relevant grant restrictions to incorporate the approved transmitters and antennas into qualified laptop/notebook/netbook and/or tablet host computer configurations. A copy of the instructions and relevant documentation must be included in the original equipment certification, subsequent Class II permissive change filings and Class I permissive change documentation
 - a) the instructions must clearly identify the minimum antenna-to-user separation distances applicable to all qualified host computer configurations and the relevant antenna installation locations and orientations for these host configurations
 - b) the instructions must clearly identify the procedures in this document, including any necessary Class I permissive change documentation, and other applicable KDB publications and inquiry responses that must be applied to determine how to incorporate multiple transmitters and antennas in qualified host computers to meet simultaneous transmission requirements and to determine if the implementations are acceptable or additional tests and certification are necessary

Appendix

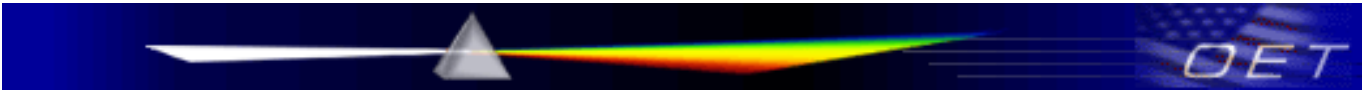
Configuring Conservative SAR Test Conditions

The following general guidance should be considered to configure the conservative SAR test conditions described by the supplemental laptop/notebook/netbook and tablet procedures in this document. *These procedures may need adjustments as transmitters and host products with varying operating configurations and exposure conditions continue to emerge. When it is unclear, a KDB inquiry should be submitted to the FCC Laboratory to determine the applicable test configurations.*

- 1) The test separation distance between the antenna or a transmitter/antenna assembly (e.g. a modular configuration) and the phantom should be chosen conservatively to cover the operating configurations and exposure conditions of the transmitter and antenna(s) in host computer configurations required for OEM integrations and other intended uses to minimize subsequent Class II permissive changes
 - a) for incorporation into tablet computers - the test separation distance also need to satisfy the *Tablet Mode* test procedures in KDB 447498 4)b)ii) for the covered tablet host configurations
- 2) The energy coupling procedures in KDB 447498 2)b)ii) are required for each configuration tested in 3) and 4) below
- 3) For implementations that require an antenna to be connected to the transmitter through RF cables(s), the antenna assembly (typically the stand-alone antenna) should be tested independently for SAR according to the following
 - a) a representative antenna cable must be used to connect the antenna to the transmitter
 - i) the antenna cable should be of the same type used in actual implementations

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- ii) the shortest antenna cable required by the host computers should be used to connect an antenna to the transmitter
 - (1) a separation distance of at least 10 cm must be maintained between the antenna and the host computer in the SAR measurement setup
 - (2) when the shortest cable cannot be used to maintain the required antenna to host computer separation distance, the measured SAR must be scaled up with respect to the shortest cable to account for cable loss differences
 - (3) the antenna cable should be routed and oriented according to the actual implementations
 - b) the transmitter must be installed in a representative host computer and operating with the actual firmware, software drivers and other associated software as required by the SAR test procedures for the different wireless technologies
 - c) the antennas must be tested in the mounting and installation orientations corresponding to the actual implementations, which are typically along the top and side edges of display screens in horizontal and vertical orientations
 - i) for antennas that are physically or electrically asymmetrical and can be installed in host computers with the different sides, edges or ends of the antenna in various orientations or rotations, these types of variations must be clearly identified and tested accordingly
 - (1) a KDB inquiry should be submitted to determine if test reduction may be considered
 - 4) When the antenna is built-in as an integral part of the transmitter, fixed and cannot be re-oriented with respect to the transmitter assembly, the following apply
 - a) the transmitter/antenna assembly, if appropriate, should be tested independently for SAR as a detached assembly
 - i) a separation distance of at least 10 cm is required between the transmitter/antenna assembly and the host computer in the SAR measurement setup
 - ii) any interface cable used to extend the assembly outside of the host computer to support this test configuration must be routed and oriented according to actual implementations
 - (1) if an interface cable is only required for testing and not used in the actual implementations, the cable should be oriented perpendicular to the E-field to minimize field perturbation during measurements
 - iii) the transmitter/antenna assembly must be tested in all installation orientations and rotations required by the host computer configurations
 - b) when step a) is not feasible or cannot be applied, installation of the transmitter/antenna assembly must be limited to the configurations tested and supported in 6)d) below
 - 5) When the average conducted output power is $\leq 60/f_{\text{(GHz)}} \text{ mW}$ and SAR evaluation is not required or when the highest measured SAR of a transmitter in 3) or 4) is $< 0.4 \text{ W/kg}$, KDB 447498 2)a)i) applies
 - a) the antenna or transmitter/antenna assembly configurations tested in 3) or 4) may be incorporated into host computer configurations according to the supplemental laptop/notebook/netbook and tablet procedures in this document
 - i) the separation distance between an antenna or transmitter/antenna assembly and the user for all host computer implementations must be greater than or equal to those tested in 3) or 4)
 - b) additional SAR testing with the antenna or transmitter/antenna assembly in representative host computers is unnecessary when applying the supplemental laptop/notebook/netbook and tablet procedures in this document
 - 6) When the highest measured SAR is ≥ 0.4 and $< 1.2 \text{ W/kg}$, the procedures in KDB 447498 2)a)ii) and 2)a)iii) apply

- a) in addition to testing the antenna or transmitter/antenna assembly in 3) or 4), the antenna or transmitter/antenna assembly should also be tested in representative laptop/notebook/netbook and/or tablet host(s)
 - i) the display screen should be positioned perpendicular to the keyboard for *Laptop Mode* and folded on top of the keyboard for *Tablet Mode*, as described in KDB 447498 4)b)
 - ii) the type of material surrounding the antenna location for the host(s) used in the tests must be similar to those in the actual implementations
 - (1) separate hosts should be tested to support different surrounding materials that are expected to introduce SAR differences; for example, non-conductive plastic vs. conductive plastic or metallic materials
- b) laptop/notebook/netbook and tablet are considered separate platforms in KDB 447498
 - i) SAR testing in a representative laptop/notebook/netbook host according to the procedures in 6)c) or 6)d) below is required
 - ii) when the highest measured SAR of a transmitter in 3) or 4) is < 0.8 W/kg, KDB 447498 2)a)ii) applies
 - (1) testing in a representative tablet host is not necessary when the minimum test separation distances for the antenna or transmitter/antenna assembly orientations tested in 6)c) or 6)d) are applicable to the tablet host configurations
 - iii) when the highest measured SAR of a transmitter in 3) or 4) is ≥ 0.8 W/kg, KDB 447498 2)a)iii) applies
 - (1) if the test separation distance is ≥ 5 cm, follow the procedures in 6)b)ii)(1)
 - (a) otherwise; testing the antenna or transmitter/antenna assembly orientations in a representative tablet host computer according to the *Laptop and Tablet Mode* test procedures in KDB 447498 4)b)ii) is required to incorporate the transmitter in tablet host configurations
- c) the antenna orientations tested in 3) should be tested in a representative laptop/notebook/netbook or tablet host using the same antenna to phantom separation distance in 3)
 - i) the appropriate sides and edges of the host computer should be oriented or positioned next to the phantom according to the antenna orientations and configurations tested in 3)
 - ii) antennas installed along the top edges of display screens should be tested
 - (1) with the top edge (antenna parallel to phantom) positioned at the separation distance used in 3), from the phantom, for horizontal antenna orientation configurations
 - (2) with the side of the display screen (antenna perpendicular to phantom) positioned against the phantom to establish a minimum antenna to phantom separation distance for vertical antenna orientation configurations
 - iii) antennas installed along the sides of display screens may be tested
 - (1) with the side edge (antenna parallel to phantom) positioned at the separation distance used in 3), from the phantom, for horizontal antenna orientation configurations
 - (2) with the top or bottom of the display screen (antenna perpendicular to phantom) positioned against the phantom to establish a minimum antenna to phantom separation distance for vertical antenna orientation configurations
- d) the transmitter/antenna assembly orientations tested in 4) should be tested in representative laptop/notebook/netbook or tablet host(s) using the same transmitter/antenna assembly to phantom separation distance in 4)



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- i) the appropriate sides and edges of the host computer should be oriented or positioned next to the phantom according to the transmitter/antenna assembly orientations and configurations tested in 4)
 - ii) transmitter/antenna assemblies installed along the lower edge of display screens or edges of the keyboard should be tested
 - (1) with the corresponding edge (assembly parallel to phantom) positioned at the required separation distance from the phantom for horizontal antenna orientation configurations
 - (a) with the bottom of the keyboard facing the phantom in *Laptop Mode* or with the corresponding edge of the keyboard and display facing the phantom in *Tablet Mode*
 - (2) with the side of the keyboard (assembly perpendicular to phantom), adjacent to the edge with the transmitter/antenna assembly, positioned against the phantom to establish a minimum transmitter/antenna assembly to phantom separation distance for vertical assembly orientation configurations
 - e) the minimum antenna or transmitter/antenna assembly to phantom separation distance tested in 6)c)ii)(2), 6)c)iii)(2) and 6)d)ii)(2) can be limited by how the antenna is installed in the host selected for testing; therefore, this can affect the conservativeness of results for supporting more conservative host configurations
- 7) When the highest SAR measured in 3), 4) or 6) is $> 1.2 \text{ W/kg}$, KDB 447498 2)c) applies
- a) SAR compliance should be evaluated according to the operating configurations and exposure conditions of the actual (dedicated) host computer(s)
 - i) depending on the location of the antenna or transmitter/antenna assembly in the host computer(s) and the simultaneous transmission configurations, when the highest measured SAR is $< 1.3 - 1.4 \text{ W/kg}$ the procedures in 6) may be considered on a case-by-case basis with prior FCC consultation for incorporation into multiple hosts with substantially similar constructions
 - b) alternatively, a larger test separation distance may be considered if it is acceptable for the intended host computer configurations
 - c) the simultaneous transmission SAR test reduction and exclusion considerations described in the supplemental procedures of this document may be applied
- 8) The antenna or transmitter/antenna assembly implementation requirements for the acceptable laptop/notebook/netbook and/or tablet host computer configurations, supported by the test results, must be clearly documented and provided to the responsible parties to incorporate qualified transmitter and antenna configurations into final products. This same documentation must be included in the RF exposure exhibit for review during equipment certification.